United States Patent

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[54] **THERMOFORMING APPARATUS**
10 Claims, 9 Drawing Figs.

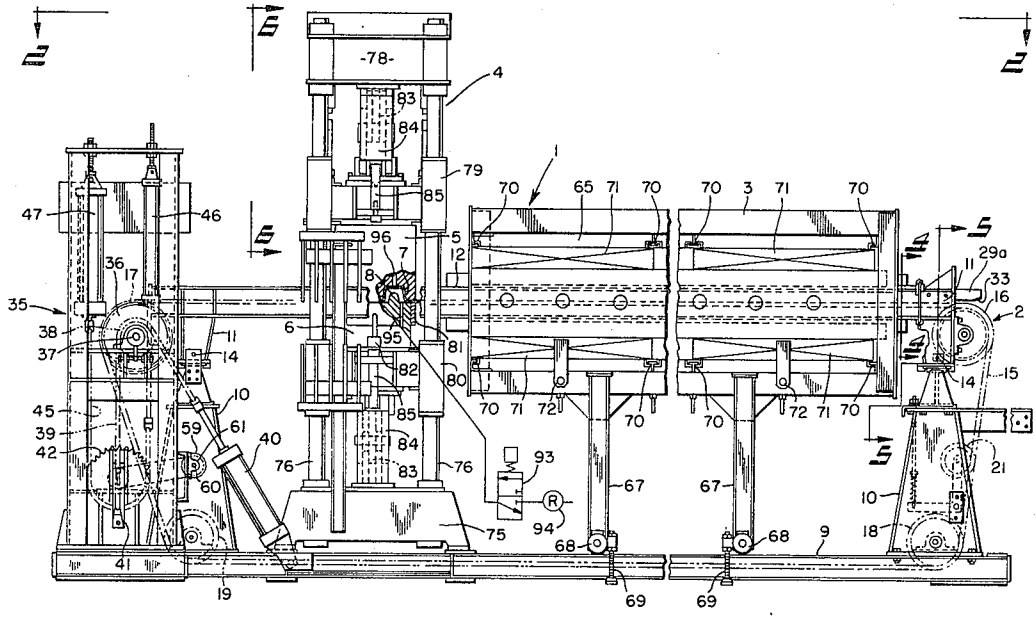
[52] **U.S. Cl.** **425/387,** 264/90, 425/388, 425/450
[51] **Int. Cl.** **B29c 17/04,** B29c 3/00
[50] **Field of Search** ..... 18/19 R, 19 F, 16 T, 16 R, 22, 35, 19 H; 264/89, 90

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ABSTRACT: Thermoforming apparatus including an oven and an adjacent thermoformer through which a plastic sheet is successively conveyed for heating the sheet for forming temperature as it is indexed through the oven and for pressure and/or vacuum forming the heated sheet in the thermoformer.



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SHEET 1 OF 6

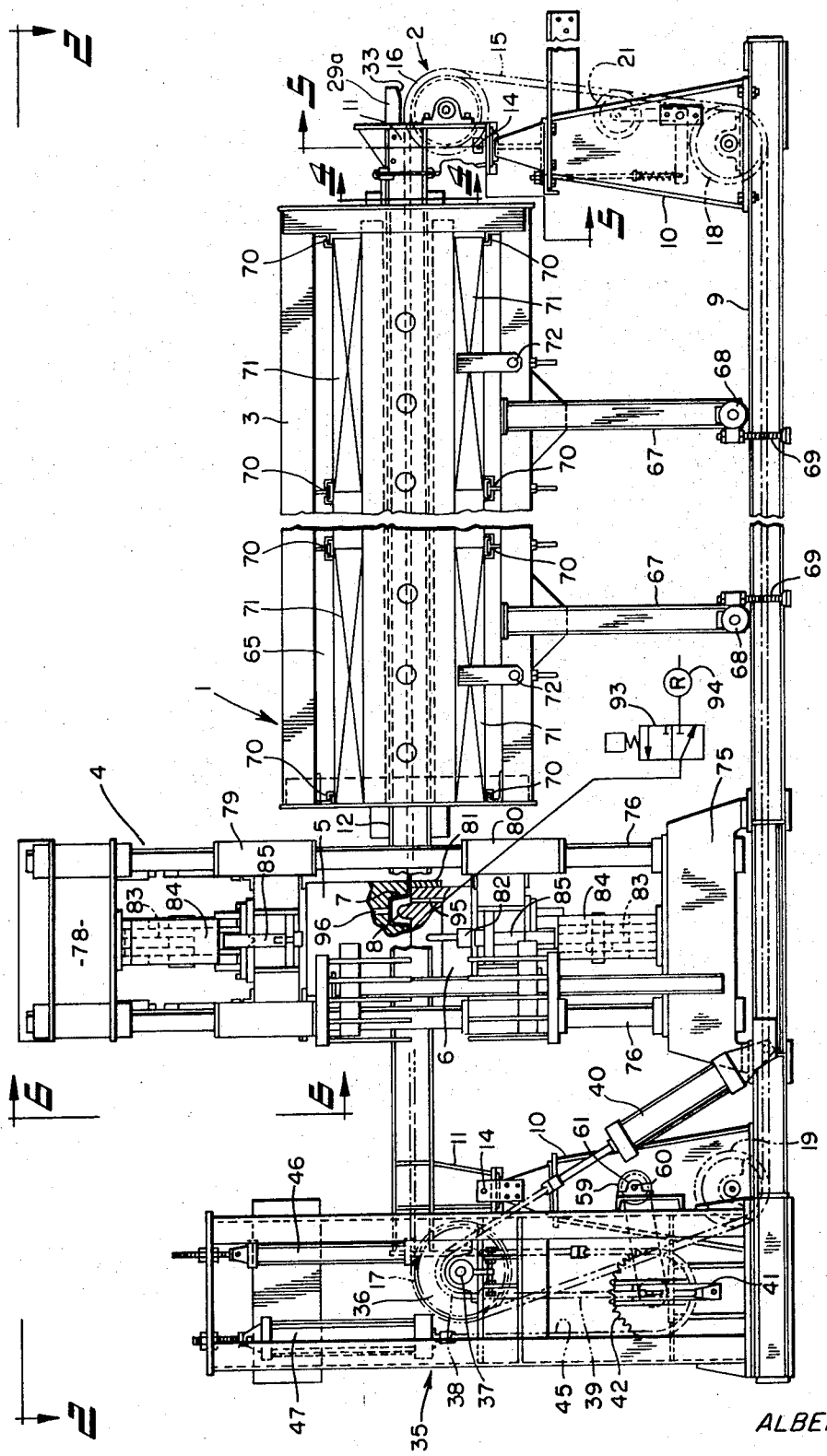


FIG. 1

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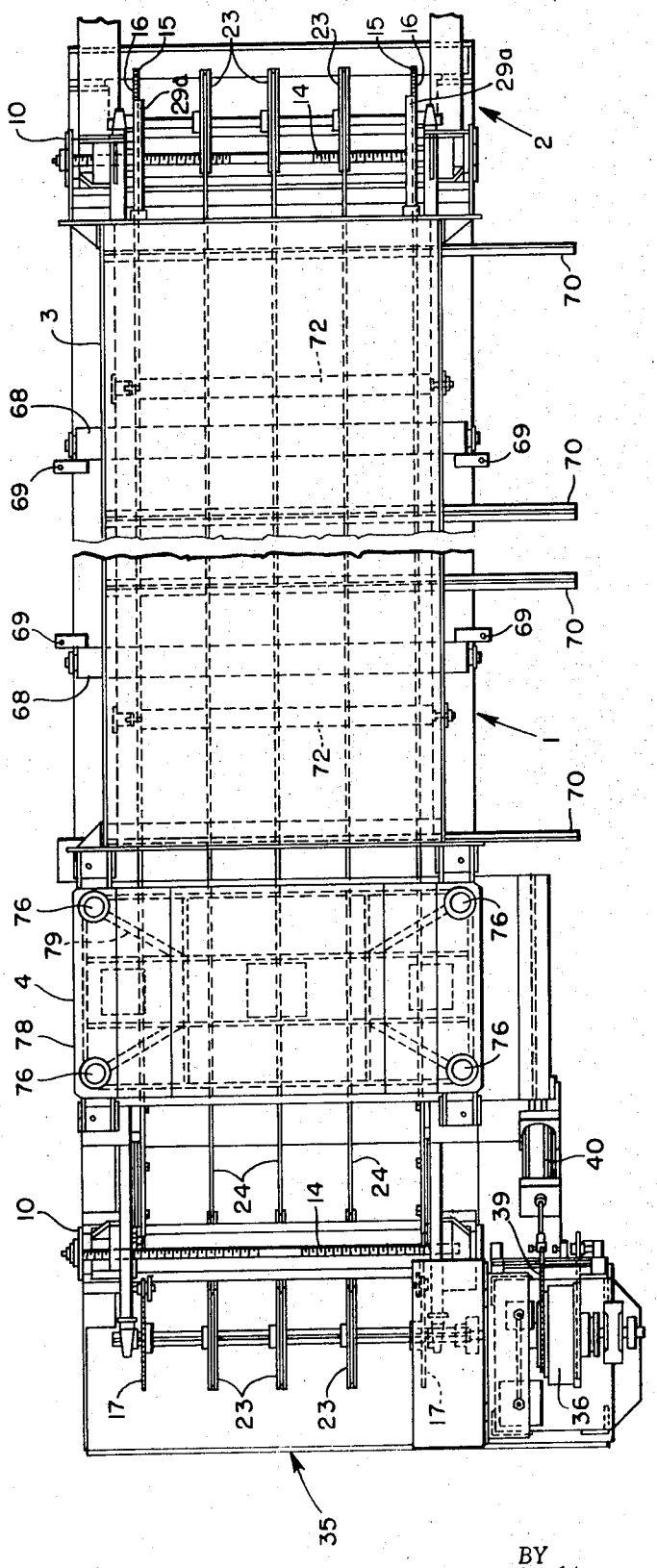


FIG. 2

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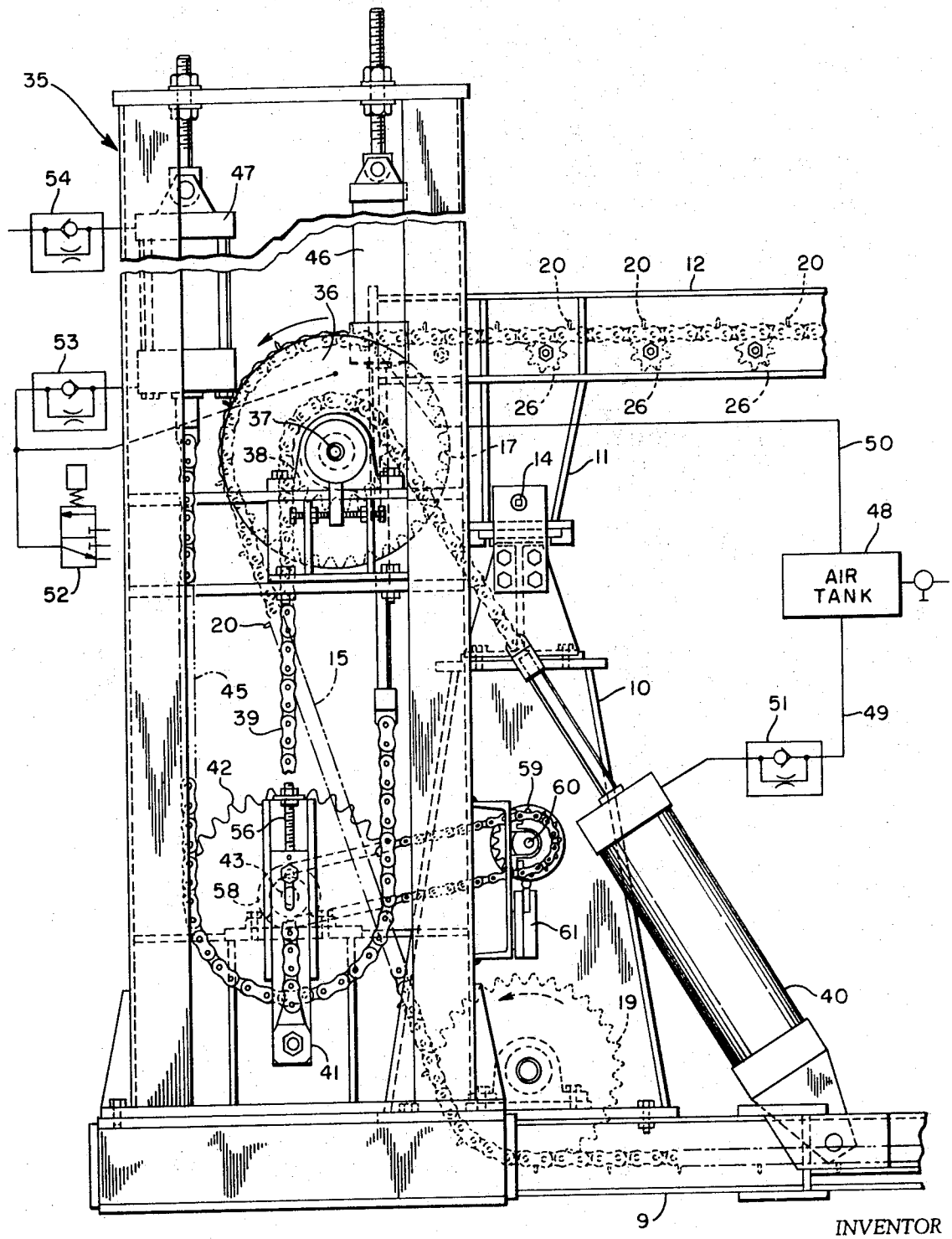


Fig. 3

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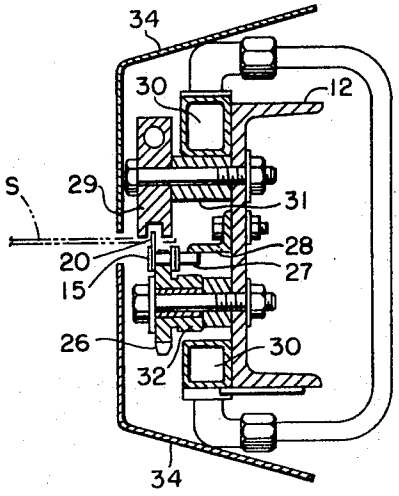


Fig. 4

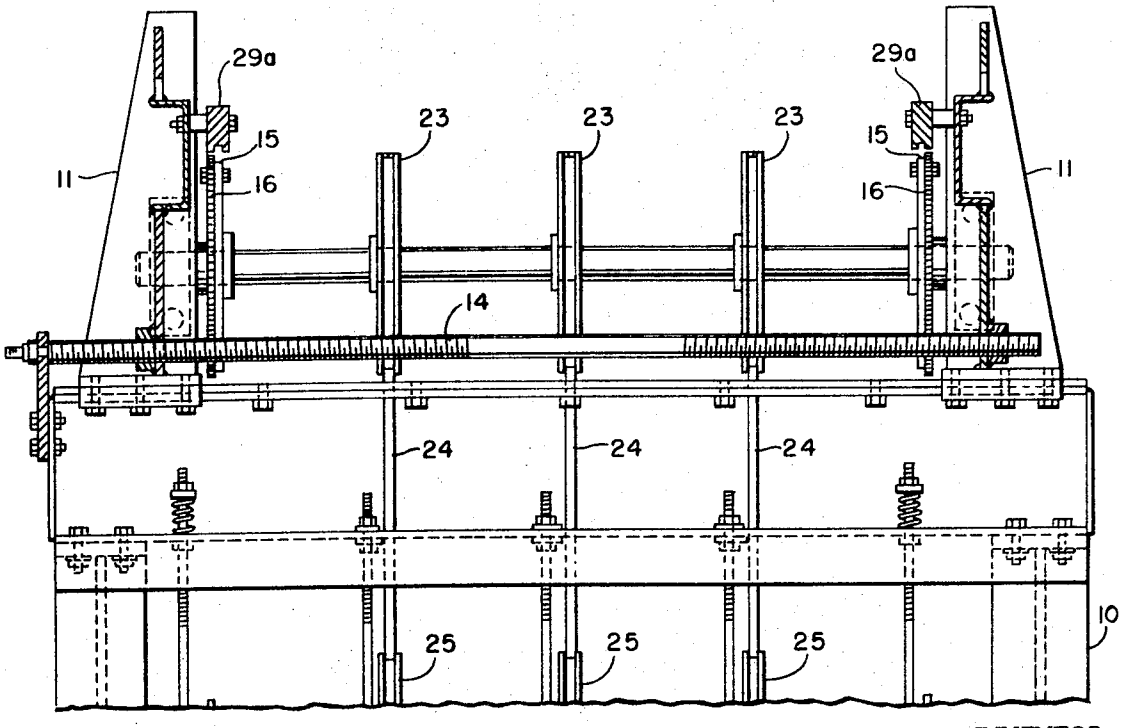


Fig. 5

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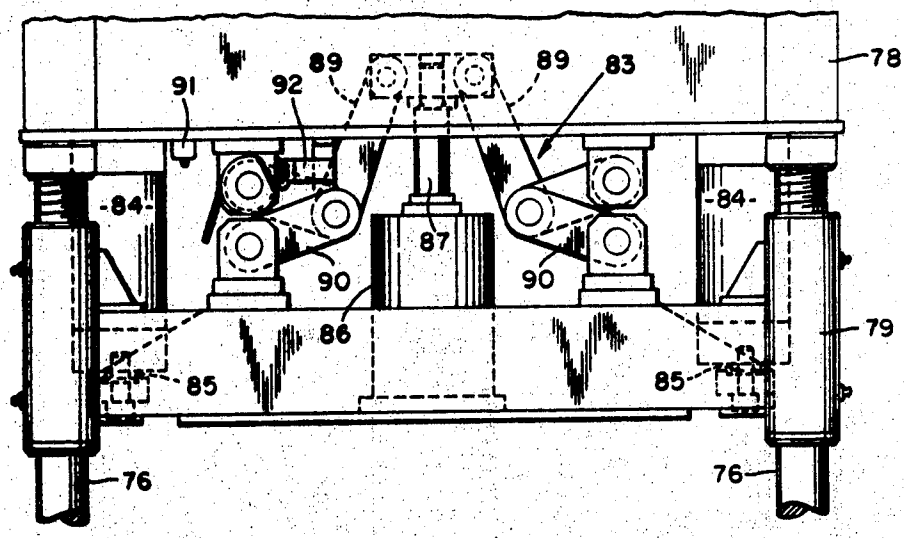


Fig. 6

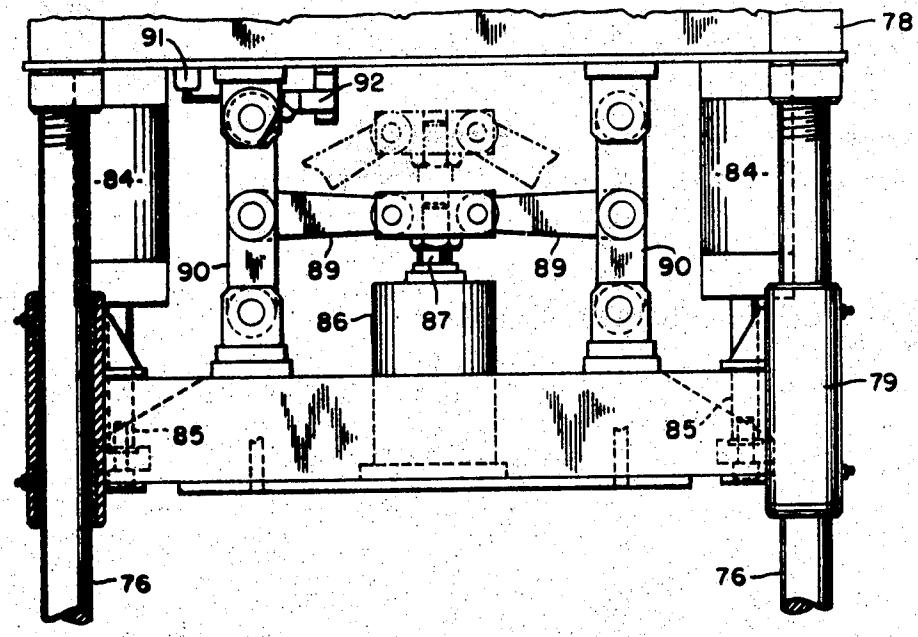


Fig. 7

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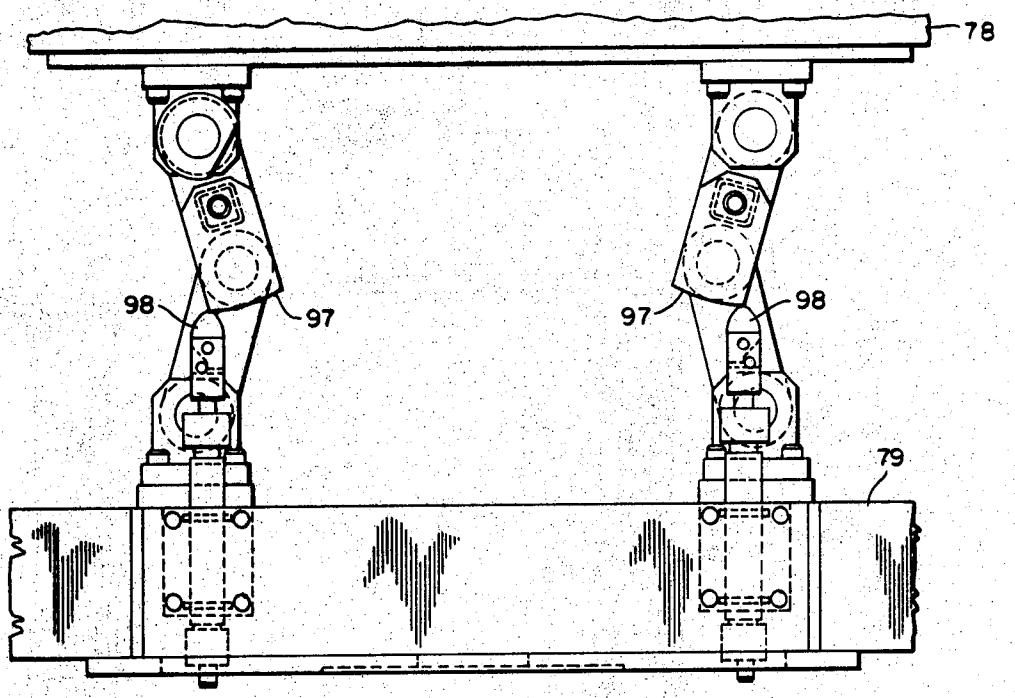


Fig. 8

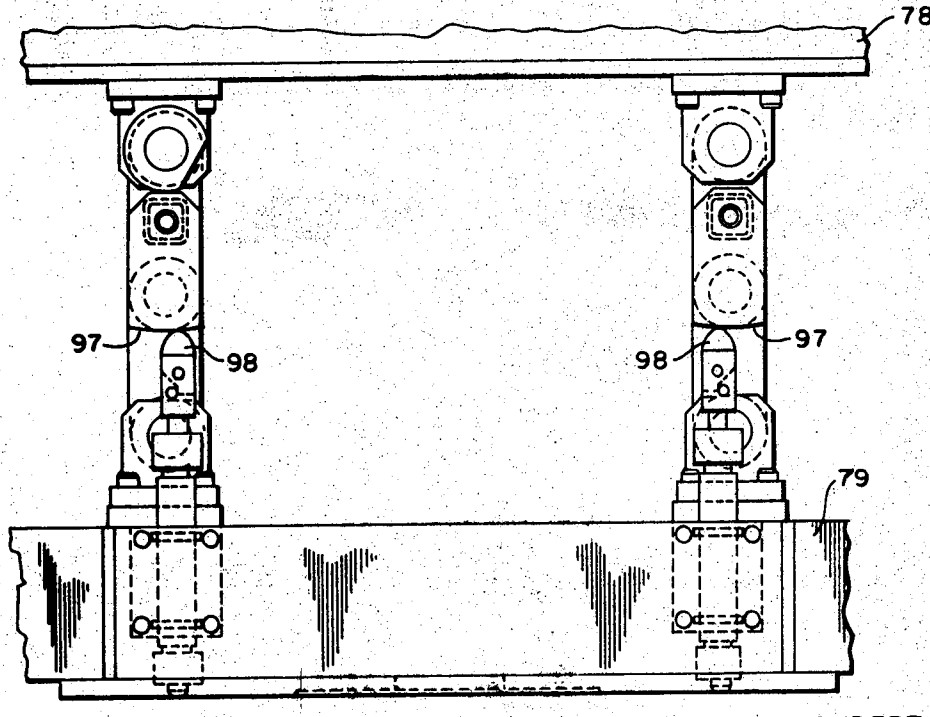


Fig. 9

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THERMOFORMING APPARATUS

BACKGROUND OF THE INVENTION

Thermoformers of the type above referred are known in the art and generally comprise a unitary base or frame structure for the oven, the thermoformer, and the sheet conveyor whereby vibrations and shock loads incident to the operation of the thermoformer and the conveyor are transmitted to each other and to the oven. Moreover, known thermoformers, by reason of their construction, require that the molds be locked together before admitting forming pressure air thereinto; otherwise there is the danger of mold separation.

Also, in known thermoformers, if the molds are locked up for preloading by use of maximum available fluid pressure on the locking cylinder, then it is impossible to unlock the molds except by use of greater fluid pressure source. Accordingly, in the operation of such thermoformers, it is customary to adjust the molds for lower preload in closing, and as a consequence, forming air pressure must be decreased and sheet temperature must be increased.

SUMMARY OF THE INVENTION

It is a principal object of this invention to provide a thermoformer so constructed as to obtain faster cycling by introduction of forming pressure air prior to the time that the molds are in locked-up position and by use of greater forming pressure air with consequent reduction in sheet-heating temperature and formed sheet setup time.

Another object is to provide a thermoformer in which the vibrations and shock loads of the thermoformer and sheet conveyor are not transmitted to each other or to the oven.

Another object is to provide a thermoformer having a novel double toggle-locking mechanism which assures accurate mold alignment and high preload lockup thereof and which further assures that unlocking may be effected by the same fluid pressure as used for locking.

Another object is to provide a thermoformer wherein the sheet conveyor has a sinusoidal speed curve to provide for smooth acceleration and deceleration of the sheet through the oven and thermoformer to minimize vibration and shock loads in the apparatus.

Another object is to provide a thermoformer wherein the top course of an endless pin chain conveyor punctures the opposite edge portions of the sheet and positively conveys the same through the heating oven and the thermoformer while being guided and cooled, the pin chain conveyor having a bottom course beneath the thermoformer and the oven.

Other objects and advantages of the present invention will become apparent as the following description proceeds.

BRIEF DESCRIPTION OF THE DRAWING

In said annexed drawing:

FIG. 1 is a side elevation view of a preferred form of thermoforming apparatus embodying the present invention;

FIG. 2 is a top plan view of the FIG. 1 apparatus as viewed along the line 2—2, FIG. 1;

FIG. 3 is a side elevation view illustrating in detail the indexing drive mechanism;

FIG. 4 is a cross section view on enlarged scale taken substantially along the line 4—4, FIG. 1;

FIG. 5 is a fragmentary cross section view on enlarged scale taken substantially along the line 5—5, FIG. 1;

FIGS. 6 and 7 illustrate unlocked and locked positions of the double toggle-locking mechanism which is employed in connection with each platen of the thermoformer; and

FIGS. 8 and 9 illustrate a preferred form of stripping mechanism which, for example, strips the formed sheet from the upper female mold as the upper and lower platens are separated from each other.

DISCUSSION OF THE INVENTION

As shown, for example, in FIGS. 1 and 2, the thermoforming apparatus 1 herein comprises an indexing pin chain conveyor 2 which transports the plastic sheet S gripped thereby through a heating oven 3 and a thermoformer 4. As the plastic sheet S gripped by the conveyor 2 is indexed through the oven 3 it is progressively heated to forming temperature and when the heated sheet S reaches an indexed position between the separated top and bottom mold sections 5 and 6 of the thermoformer 4, the mold sections 5 and 6 are brought together to grip and seal against the sheet S whereupon the sheet S may be formed into the female cavities 7 in the top mold 5 by plug assist members 8 in the bottom mold 6, by air pressure in the bottom mold 6, and by vacuum in the top mold 5. After the sheet S has thus been formed, the molds 5 and 6 are separated and the sheet S is again indexed to bring the next heated section thereof between the separated molds 5 and 6 for repetition of the foregoing operation.

THE SHEET CONVEYOR

Referring to FIGS. 1 to 5, the sheet conveyor 2 comprises a base including parallel bottom rails 9 and standards 10 adjacent each end, the latter having the slide members 11 of parallel top rails 12 laterally adjustable on said standards 10 as by rotary screw means 14 to accommodate different widths of plastic sheet S which it is desired to convey between the top rails 12.

The indexing conveyor 2 comprises a pair of pin chains 15 trained over sprocket wheels 16–17 on slide members 11 adjacent the ends of the top rails 12 and over sprocket wheels 18–19 disposed adjacent the ends of the base rails 9. The pin chains 15 have links provided with points 20 which, when engaged with the adjacent edges of the sheet S to be indexed through the apparatus 1, are effective to puncture the sheet S, thus to firmly grip the same for positive indexing movement through the oven 3 and through the thermoformer 4. As shown in FIG. 1, the chains 15 are maintained taut as by means of a spring-loaded idler sprocket wheel 21. The shafts for the respective pairs of sprocket wheels 16, 17, 18, and 19 may have adjustably mounted thereon sag band sheaves 23 over which are trained the bands 24 which support the plastic sheet S against sagging as it passes through the oven 3, spring loaded takeup sheaves 25 being provided to maintain the sag bands 24 taut.

As best shown in FIG. 4, each top rail 12 has secured thereto idler sprockets 26 at spaced intervals longitudinally therealong along which the respective pin chain 15 travels. Each chain 15 has projecting pin portions 27 engaged with an angle 28 secured to each rail 12, said pin portions 27 maintaining the pin axes parallel to the plane of the sheet S during puncturing of the sheet as the sheet enters the conveyor 2 and during the indexing of the chains 15 and sheet S through the apparatus. Located above the gripped edges of the sheet S are sheet and chain guide bars 29, as of extruded aluminum, which are hollow as shown for circulation of a suitable coolant medium, such as water, therethrough, thus to cool the sheet edges and the chains 15. Further coolant ducts 30 are provided for circulation of water therethrough to cool the respective rails 12, the guide bar bushings 31, and the idler sprocket bushings 32. In addition, heat shields 34 are provided above and below the gripped edges of the sheet S thus to prevent excessive heating of the edge portions of the sheet S. The guide bars 29A at the right in FIGS. 1 and 2 (also see FIG. 5) are solid steel bars and have cam surfaces 33 to guide the leading end of the sheet S.

THE CONVEYOR-INDEXING MECHANISM

As best shown in FIGS. 1, 2, and 3, the conveyor-indexing mechanism 35 comprises a pneumatic clutch 36 on the sprocket shaft 37 for sprockets 17 at the left as shown in FIG. 1, and trained over a sprocket 38 which drives the shaft 37

when the clutch 36 is engaged and which moves freely in the opposite direction when the clutch 36 is disengaged, is a chain 39 having one end connected to a pneumatic cylinder or air spring 40 and the other end connected to an adjustable crank arm 41 on a sprocket 42 journaled on a jackshaft 43. Trained over said sprocket 42 is another length of chain 45, one end of which is connected to an air spring 46, and the other end of which is connected to an actuating cylinder 47 which has a stroke equal to one-half revolution of the sprocket 42. As clearly shown in FIG. 3 the rod ends of cylinders 40 and 46 are in constant communication with an air pressure tank 48 through conduits 49 and 50, conduit 49 having therein a choke-check valve 51, and the head ends of said cylinders 40 and 46 are vented to the atmosphere.

When the solenoid valve 52 (FIG. 3) is energized, air under pressure flows through said valve 52 to engage the clutch 36 and to enter the rod end of cylinder 47 via a choke-check valve 53 while the head end is vented through choke-check valve 54. As evident, when air under pressure is admitted into the lower rod end of the indexing cylinder 47, the crank sprocket 42 is turned 180°from its upper position to the lower FIGS. 1 and 3 position. Such 180°clockwise movement of the crank sprocket 42 turns the now engaged drive sprocket 38 in a counterclockwise direction through the chain 39, whereby the chains 15 and the sheet S gripped thereby are indexed a predetermined amount depending on the radius of the crank arm 41, the radius being adjustable as by means of the screw 56, as shown in FIG. 3.

It is to be noted that by reason of the 180° clockwise rotation of the crank sprocket 42, the turning of the drive sprocket 38 and shaft 37 will cause a sinusoidal speed curve of the chains 15 to produce a gradual acceleration and deceleration from one indexed position to the next. When the solenoid valve 52 is deenergized, the clutch 36 is disengaged, and the lower end of the indexing cylinder 47 is connected to the atmosphere through the choke check 53 and valve 52 whereby tank pressure in air springs 40 and 46 is effective to turn the released drive sprocket 38 in a clockwise direction for return of the crank arm 41 to its upper position, i.e., the position where the crank arm 41 is disposed 180° counterclockwise from the position shown in FIG. 3.

The crank sprocket shaft 43 may have thereon other sprockets 58 such as the one shown in FIG. 3, which drives sprockets 59 to actuate a camshaft 60 to actuate suitable switches 61 to initiate closing operation of the thermoformer 4 after the heated sheet S from the oven 3 has been indexed to a position between the separated molds 5 and 6.

THE HEATING OVEN

The heating oven 3 as shown in FIGS. 1, 2, comprises an enclosure 65 open at its respective ends for entrance and egress of the plastic sheet S transported therethrough by means of the aforesaid pin chain conveyor 2. This oven enclosure 65 is supported as on legs 67 equipped with flanged rollers 68 movable on the base rails 9 but having jack screws 69 associated therewith whereby the flanged rollers 68 may be disengaged from the rails 9 thus to support the oven 3 independently of the supports for the pin chain conveyor and drive means 2 and 35 and for the thermoformer 4, as hereinafter explained in detail.

The oven 3 is provided with transversely projecting guide rails 70 which are adapted to mount drawerlike units 71 containing electric heating elements which are disposed in spaced relation above and below the plastic sheet S which is transported through the oven 3. In the event of overheating of the sheet S in the oven 3, photocell or like sag-sensing means (not shown) may be provided so that pneumatic cylinders 72 may be actuated to pull out at least the bottom heater units 71 from underneath the plastic sheet S when such excessive sag occurs. In this way, there is provided quick and prompt action to prevent melting of the sheet S in the oven 3 as might occur if the bottom heater units 71 were merely deenergized. If desired, or necessary, the top units 71 may similarly be actuated for displacement out of superimposed relation with respect to the sheet S. In the present case, it is preferred that the oven 3 be of length say, 4 times the indexing stroke of conveyor 2 whereby the sheet S may be gradually heated to forming temperature in uniform stages as the sheet is indexed 4 times prior to reaching the thermoformer 4. In this way, gradual and uniform heating of the sheet is assured since the heating is accomplished in a time interval corresponding to four indexing movements.

THE THERMOFORMER

The thermoformer 4 herein comprises a base 75 from which two pairs of posts or tie bars 76 extend upwardly and straddle the chain guide rails 12. Adjustably secured at the upper ends of said posts 76 is an upper head 78. Vertically reciprocably mounted on said posts 76 are the respective top and bottom movable platens 79 and 80 which, as well known in the art, will have mounted thereon the respective top female and bottom male plug assist molds 5 and 6, and associated with the bottom mold 6 will be a clamping frame 81 actuated as by pneumatic cylinders 82 between said frame 81 and the bottom platen 80 to position the clamp frame 81 underneath the plastic sheet S and in clamped relation to the female mold 5 when the latter is moved downwardly to molding position.

In the present case, double toggle lock mechanisms 83 are provided and because the upper and lower ones are substantially the same, only the upper one 83 has been illustrated in detail in FIGS. 6 and 7.

As shown in FIGS. 6 and 7, the top head 78 has secured thereto a pair of depending cylinders 84 of which the piston rods 85 are connected as shown to the top platen 79.

Also as shown in FIGS. 6 and 7, the top platen 79 carries a lock cylinder 86 having its piston rod 87 connected to a first pair of toggle links 89 and, in turn, the toggle links 89 are connected to the knee joints of toggle linkages 90 which are pivotally connected to head 78 and platen 79. When the clamp frame cylinders 82 and the platen cylinders 84 are actuated, the clamp frame 81 is brought to a position to seal against the bottom side of the heated plastic sheet S, and the platens 79 and 80 are moved toward each other while the lock cylinders 86 are idling i.e. both ends vented. When the toggle linkages 90 are a few degrees from dead center locking position, the switches 91 are closed to admit locking air pressure into the rod ends of the lock cylinders 86 to actuate them from the FIG. 7 dot-dash position to the FIG. 7 solid line locking position whereat the links 89 and linkages 90 are in dead center locked positions. The last 1 inch or so of the strokes of the lock cylinders 86 are cushioned to provide a time delay for gradual positive lockup. At about the same time that switches 91 are closed, the switches 92 are closed to open the solenoid valve 93 for flow of forming pressure air from pressure regulator 94 into passages 95 in the bottom male mold 6 to deform the plastic sheet S to final form conforming to the female cavities 7. At the time that the plug assist members 8 initially contact the plastic sheet S the vented vacuum passages 96 in the top mold 5 are partially blocked to control the billowing of the plastic sheet S over the plug assist members 8. Thereafter, the vacuum passages 96 are opened to suction to assist in pulling the sheet S toward the female cavities 7 and then, finally, starting before lockup, forming pressure air is admitted through passages 95 to complete the forming operation.

After the plastic sheet S has thus been formed air is admitted into the head ends of the lock cylinders 86 and into the rod ends of the cylinders 84 to effect unlocking of the toggle mechanism 83 and to open switches 92 to vent passages 95 through solenoid valve 93. Also, the vacuum passages 96 are vented to the atmosphere.

THE STRIPPING MECHANISM

As the toggle mechanism 83 of the top platen 79 is unlocked from the FIG. 9 to the FIG. 8 position cams 97 bear down on

spring-loaded stripper pins 98. The top mold 5 will have therein a stripper plate (not shown) engaged by the lower ends of the stripper pins 98 thus to free the formed sheet S from the female cavities 7.

I, therefore, particularly point out and distinctly claim as my invention:

1. Thermoforming apparatus comprising a first mold having a female cavity; a second mold through which fluid under pressure is admitted to act on a heated plastic sheet adapted to be clamped between said molds to deform the sheet against said female cavity; mold-actuating mechanism including linkage means for relatively moving said molds to closed and locked position with the heated sheet in such locked position being clamped therebetween; and means for conducting fluid under pressure to said second mold comprising valve means operative when opened to conduct fluid under pressure to said second mold, and valve-operating means actuated by said linkage means to open said valve means prior to the time that said linkage means reaches such mold-locking position and thereafter.

2. The apparatus of claim 1 wherein a double-acting lock cylinder operatively connected to said linkage means is so arranged that at the same cylinder-actuating fluid pressure the mold-unlocking force exerted thereby is greater than the mold-locking force.

3. The apparatus of claim 1, wherein said linkage means includes a double toggle linkage having a first pair of toggle linkages disposed between a fixed member on said thermoformer and one of said molds, said first pair of toggle linkages in their locking position constituting struts between said fixed member and said mold, and having a second toggle linkage which, during movement to said locking position, spreads apart said first pair of linkages toward locking position.

4. The apparatus of claim 3, wherein a lock cylinder on said one mold has its piston rod connected to said second linkage to actuate the latter and said first pair of linkages between locking and unlocking positions.

5. Thermoforming apparatus comprising an arrangement of vertical tie bars having upper and lower heads affixed thereto; upper and lower platens between said heads vertically movably guided on said bars; upper and lower molds on said platens; actuating mechanisms between the respective heads and platens to lock said molds together in clamping relation to a heated plastic sheet therebetween for deformation thereof into a cavity in one of said molds by fluid under pressure admitted through the other one of said molds; each mechanism including at least one actuating cylinder between each head and platen operative to move the latter to a position in which the molds are closely adjacent, a first pair of toggle linkages pivotally connected to the respective head and platen, a second toggle linkage between said first pair of toggle linkages, and actuating means between said second toggle linkage and the respective platen operative to move said second toggle linkage to locking position to spread apart said first pair of toggle linkages to locking position thus to move said molds into locking position, to securely lock the respective platen against movement toward the respective head, and to preload said bars to preclude mold separation during forming of the heated sheet.

6. The apparatus of claim 5 wherein said actuating means comprises a lock cylinder on each platen having a piston rod pivotally connected to said second toggle linkage to actuate said linkages to platen locking and unlocking positions, said lock cylinder being in idling condition when said actuating cylinders are moving said molds to said closely adjacent position.

7. The apparatus of claim 6 wherein said lock cylinders are double acting and are so arranged that at the same cylinder actuating fluid pressure the mold unlocking force exerted thereby is greater than the mold locking force.

8. The apparatus of claim 5 wherein valve means when opened conducts fluid under pressure into said other mold; and wherein valve-operating means actuated by one of said first pair of toggle linkages opens said valve means prior to the time that said first pair of toggle linkages and said second toggle linkage reach mold-locking position and thereafter.

9. The apparatus of claim 1 wherein said valve means comprises a solenoid-operated valve; and wherein said valve-operating means comprises a switch which is closed by said linkage means to energize the solenoid of said valve and thus open said valve as aforesaid.

10. Thermoforming apparatus comprising a first mold having a female cavity; a second mold through which fluid under pressure is admitted to act on a heated plastic sheet adapted to be clamped between said molds to deform the sheet against said female cavity; mold-actuating mechanism including linkage means for relatively moving said molds from opened and unlocked position whereat a deformed sheet may be withdrawn from between said molds and a heated sheet positioned therebetween to closed and locked position with the heated sheet in such locked position being clamped therebetween; valve means operative when opened to conduct fluid under pressure to said second mold and when closed to vent such fluid under pressure therefrom; and valve-operating means actuated by said linkage means to open and close said valve means respectively prior to the time that said linkage means reaches such mold-locking position and after said linkage means commences to relatively move said molds to opened and unlocked position.

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